WHAT IS CLAIMED IS:

1.   The method of using a scan-deflectable
ultraviolet laser beam to correct an astigmatic
condition of an eye, by selectively ablating the
external surface of the cornea, which comprises focusing
5   the laser beam to an elemental spot size which is but a
small fraction of the area of the cornea to be subjected
to ablation, and scanning the laser beam over the
locally involved area with beam-exposure flux at a level
at which resultant corneal-tissue ablation per scan is
10   to an elemental depth which is but a fraction of desired
maximum ablation into the stroma region of the cornea,
the scanning of said area being in a pattern to impact
the cornea with greatest and substantially uniform
density of laser-beam exposure per unit area along a
15   central line of symmetry across said area and through
the optical center, said pattern being further
characterized by laser-beam exposure density decreasing
smoothly with increasing lateral offset on both sides of
said central line of symmetry, said central line of
20   symmetry being oriented to accord with a pre-ascertained
determination of the cylindrical-axis orientation of the
astigmatic condition.

2.   The method of claim 1, in which said pattern
has a limiting circular perimeter which is centered on
the optical axis of the eye.

3.   The method of claim 1, in which the pattern of
scan action is one of scanning successive lapped areas
of progressively changing width, distributed
symmetrically between opposed parallel sides which are
parallel to and at equal and opposite offset from the
central line of symmetry.

4.   The method of claim 1, in which the laser is a
pulsed laser.

5.   The method of claim 1, in which the laser is a
continuous-wave laser.

6.   The method of claim 1, in which the pattern of
area scanning is two-axis rectilineal, wherein line
scanning in a first-axis component is oriented to accord
with said cylindrical-axis orientation, and wherein
scan-line depression in a second-axis component is
substantially orthogonal to said cylindrical-axis
~~orientation.~~

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7.   Astigmatism-correcting apparatus for operation
upon a limited central area of the external surface of
the cornea of an eye, comprising laser means having a
chassis and producing an output beam in the ultraviolet
portion of the electromagnetic spectrum and
characterized by a spot which at eye impingement is
small relative to said central area, scan-deflection
means positioned for deflection of said beam in a
limited field about a central axis, body-engageable

10   means for steadying one eye of the patient with respect

      to said chassis and with the central area of the cornea

      centered on the central axis of scan deflection of said

      beam, said scan-deflection means having X-Y coordinates

      of deflection for area coverage at least within the

15   perimeter of said central area, adjustable means for

      angular selection of the orientation of said coordinates

      to position one to the exclusion of the other of said

      coordinates in oriented alignment with the astigmatism

      axis of the eye to be operated upon, and means including

20   a microprocessor for establishing a series of different

      centrally related perimeter limits of rectangular-area

      scan action within the perimeter of said central area

      and for coordinating the operation of said scan-

      deflection means in a controlled program of limitation

25   of one area scan within one perimeter limit before

      repeating such coordination within the next-successive

      perimeter limit in the series, the successively scanned

      areas being of varying width and symmetrical about a

      central axis aligned with said astigmatism axis, said

30   laser means including means for adjusting beam-exposure

      flux to a level at which resultant corneal-tissue

      ablation per unit time is to an ascertained elemental

      depth which is but a fraction of desired maximum depth

      of ablation into the stroma region of the cornea,

35   whereby ablative penetration to said maximum depth is

      the cumulative result of plural area scans of each of a

      succession of different but overlapping rectangular

      areas.

8.   Astigmatism apparatus according to claim 7, and
including means for effectively limiting to the·
perimeter of said central area the component of scan in
said one-coordinate orientation.

9.   Sculpture apparatus for reduction of an
ascertained astigmatic condition in the central area of
the external surface of the cornea of an eye of a
patient, comprising laser means having a chassis and
5   producing an output beam in the ultraviolet portion of
the electromagnetic spectrum and characterized by a spot
which at eye impingement is small compared to said area,
scan-deflection means positioned for deflection of said
beam in a limited field about a central axis,
10   body-engageable means for steadying one eye of the
patient with respect to said chassis and with the
central area of the cornea centered on the central axis
of scan deflection of said beam, said scan-deflection
means having two coordinates of deflection for area
15   coverage within the perimeter of said central area, said
laser including means for adjusting beam-exposure flux
to a level at which resultant corneal-tissue ablation
per unit time is to an ascertained elemental depth which
is but a fraction of desired maximum depth of ablation
20   into the stroma region of the cornea, and means
including a microprocessor for coordinating the
operation of said scan-deflection means in a controlled
program of area coverage to establish greatest
cumulative beam exposure along the alignment of the

25 central axis of symmetry of the ascertained astigmatic
condition, with cumulative beam exposure decreasing
smoothly as a function of increasing lateral offset on
both sides of said central axis of symmetry.

10.   The method of using an ultraviolet laser beam
to change optical properties of an eye having both
astigmatic and myopia errors, by selectively ablating
the external surface of the cornea, which method
5 comprises confining the laser beam to a projected spot
which is small compared to the area containing said
errors, adjusting the intensity of laser-beam projection
to a limited level at which resultant corneal-tissue
ablation per unit time is to an ascertained elemental
10 depth which is but a fraction of a maximum ablation
depth, said maximum ablation depth having been
predetermined as necessary to reduce to substantially
zero the cylindrical curvature responsible for the
astigmatism, scanning said spot over a plurality of
15 elongate rectangular-area scans which are centered along
an elongate line of symmetry oriented on the corneal
diameter which corresponds to the axis of astigmatic
error, said rectangular-area scans being of varying
width on opposite lateral sides of said line of
20 symmetry, whereby an astigmatism-correcting change may
be effected in the cornea to thereby leave essentially
only spherical error to be corrected; then subjecting
the laser beam to a series of scans of circular areas
centered on and within the maximum area of the cornea to

25   be subjected to myopia-correction ablation, said series
      being characterized by varying outer radius, whereby a
      myopia-correcting change may be effected in the
      curvature of the cornea.

      11.   The method of using an ultraviolet laser beam
      to change optical properties of an eye having both
      astigmatic and hyperopia errors, by selectively ablating
      the external surface of the cornea, which method
5   comprises confining the laser beam to a projected spot
      which is small compared to the area containing said
      errors, adjusting the intensity of laser-beam projection
      to a limited level at which resultant cornea-tissue
      ablation per unit time is to an ascertained elemental
10   depth which is but a fraction of a maximum ablation
      depth, said maximum ablation depth having been
      predetermined as necessary to reduce to substantially
      zero the cylindrical curvature responsible for the
      astigmatism, scanning said spot over a plurality of
15   elongate rectangular-area scans which are centered along
      an elongate line of symmetry oriented on the corneal
      diameter which corresponds to the axis of astigmatic
      error, said rectangular-area scans being of varying
      width on opposite lateral sides of said line of
20   symmetry, whereby an astigmatism-correcting change may
      be effected in the cornea to thereby leave essentially
      only spherical error to be corrected; then subjecting
      the laser beam to a series of scans of circular annuli
      centered on corneal area to be subjected to hyperopia-

25   correcting ablation, said series being characterized by
      constant outer radius equal to that of said corneal area
      and being further characterized by varying inner radius
      of the annuli of successive area scans, whereby a
      hyperopia-correcting change may be effected in the
30   curvature of the cornea.

      12.   Sculpture apparatus for operation upon the
      external surface of the cornea of an eye of a patient,
      comprising laser means having a chassis and producing an
      output beam in the ultraviolet portion of the
5   electromagnetic spectrum, scan-deflection means
      positioned for deflection of said beam, and body-
      engageable means for steadying one eye of the patient
      with respect to said chassis and with a corneal portion
      of said one eye within a field traversed by scan
10   deflection of said beam, said scan-deflection means
      being operative to produce a circular sweep of beam
      travel about the center of the cornea and including
      further means for changing the radius of circular sweep,
      and means including a microprocessor for coordinating
15   the operation of said scan-deflection means with that of
      said further means in a controlled program of successive
      circular sweeps of said beam with at least one discrete
      radius of circular sweep.

      13.   Apparatus according to claim 12, in which said
      last-defined means further coordinates effective
      deactivation of said output beam in periods of changing
      radius of circular sweep.

14.   Apparatus according to claim 12, in which said last-defined means coordinates effective deactivation of said output beam at predetermined angular intervals within each circular sweep, thereby operating upon the eye in a regular succession of angularly spaced circular arcs.

15.   Apparatus according to claim 14, in which said last-defined means coordinates effective deactivation of said output beam at predetermined angular intervals within each circular sweep at each of plural radii of circular sweep.

16.   Apparatus according to claim 15, in which the angular intervals at one radius are in staggered interlace with the angular intervals at an adjacent radius of circular sweep.

17.   Apparatus according to claim 12, wherein said laser means includes means for adjusting the beam-exposure flux to a level at which resultant corneal-tissue ablation per unit time is to an ascertained elemental depth which is but a fraction of desired maximum depth of ablation into the stroma region of the cornea, whereby ablative penetration to said maximum depth is the cumulative result of plural scans of each locus of circular sweep.

18.　The method of using a scan-deflectable ultra-
violet laser beam to selectively ablate the external
surface of a cornea, which comprises limiting the laser
beam to an elemental spot size which is but a small

5　fraction of the area of the cornea to be subjected to
ablation, and scanning the laser beam in an angularly
spaced plurality of arcuate sweeps within the locally
involved area with beam-exposure flux at a level at
which resultant corneal-tissue ablation per sweep is to

10　an ascertained elemental depth which is but a fraction
of desired maximum ablation into the stroma region of
the cornea, said arcuate sweeps being between
predetermined angular limits within a full circle at
predetermined radius, and such scanning continuing with

15　repetition of radial sweeps until reaching a
predetermined depth of ablation for each arcuate sweep,
whereby a keratotomy is performed upon the cornea.

19.　The method of claim 18, wherein said predeter-
mined radius is one of a plurality of discrete radii of
arcuate sweeps.

20.　The method of claim 19, wherein the predeter-
mined angular limits of arcuate sweeps at one radius are
in angularly staggered interlace with the angular limits
of arcuate sweeps at a different one of said radii.

21.　The method of using a scan-deflectable
ultraviolet laser beam to perform a keratotomy by

selective ablation of the external surface of a cornea,
which comprises limiting the laser beam to an elemental
spot size which is but a small fraction of the area of
the cornea to be subjected to ablation, activating said
beam and radially sweeping the activated beam at each of
an angularly spaced plurality of predetermined radial
orientations within said area, the radial sweeps at said
orientations being between predetermined inner and outer
radial limits, and arcuately sweeping said beam in
periods of angular indexing from one to another of
radial sweeps at said predetermined radial orientations,
the beam-exposure flux being limited to assure ablative
photodecomposition to the extent of only partial
penetration of the cornea.

22.   The method of using a scan-deflectable ultra-
violet laser beam to perform a keratotomy which will
correct an astigmatic correction by selective ablation
of the external surface of a cornea, which comprises
limiting the laser beam to an elemental spot size which
is but a small fraction of the area of the cornea to be
subjected to ablation, activating said beam and radially
sweeping the activated beam at each of at least a pair
of diametrically opposed locations on an orientation
selected to accord with the axis of the astigmatic
condition to be corrected, the radial sweeps at said
orientation being between predetermined inner and outer
radial limits, the beam-exposure flux being limited to
assure ablative photodecomposition to the extent of only
partial penetration of the cornea.

23.   The method of using a scan-deflectable ultra-
violet laser beam to perform a keratotomy which will
correct an astigmatic correction by selective ablation
of the external surface of a cornea, which comprises
limiting the laser beam to an elemental spot size which
is but a small fraction of the area of the cornea to be
subjected to ablation, activating said beam and radially
sweeping the activated beam to execute a radial incision
at each of at least a pair of diametrically opposed
locations on an orientation selected to accord with the
axis of the astigmatic condition to be corrected, the
radial sweeps at said orientation being between
predetermined inner and outer radial limits, and
sweeping said beam transversely of each radial incision
and with substantial symmetry of offset with respect to
each radial incision, the beam-exposure flux being
limited to assure ablative photodecomposition to the
extent of only partial penetration of the cornea.

24.   The method of using a scan-deflectable ultra-
violet laser beam to perform a keratotomy which will
correct a condition of combined astigmatism and myopia
by selective ablation of the external surface of a
cornea, which comprises limiting the laser beam to an
elemental spot size which is but a small fraction of the
area of the cornea to be subjected to ablation,
activating said beam and radially sweeping the activated
beam to execute a radial incision at each of an
angularly spaced plurality of predetermined radial
orientations within said area, the radial sweeps at said

orientations being between predetermined inner and outer
radial limits, at least a pair of said orientations
being diametrically opposed and selected to accord with
15   the axis of the astigmatism to be corrected, and
sweeping said beam transversely of each of the radial
incisions of said pair, the transverse sweeps being with
substantial symmetry of offset with respect to the
respective radial incisions of said pair, the beam-
20   exposure flux being limited to assure ablative
photodecomposition to the extent of only partial
~~penetration of the cornea.~~

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